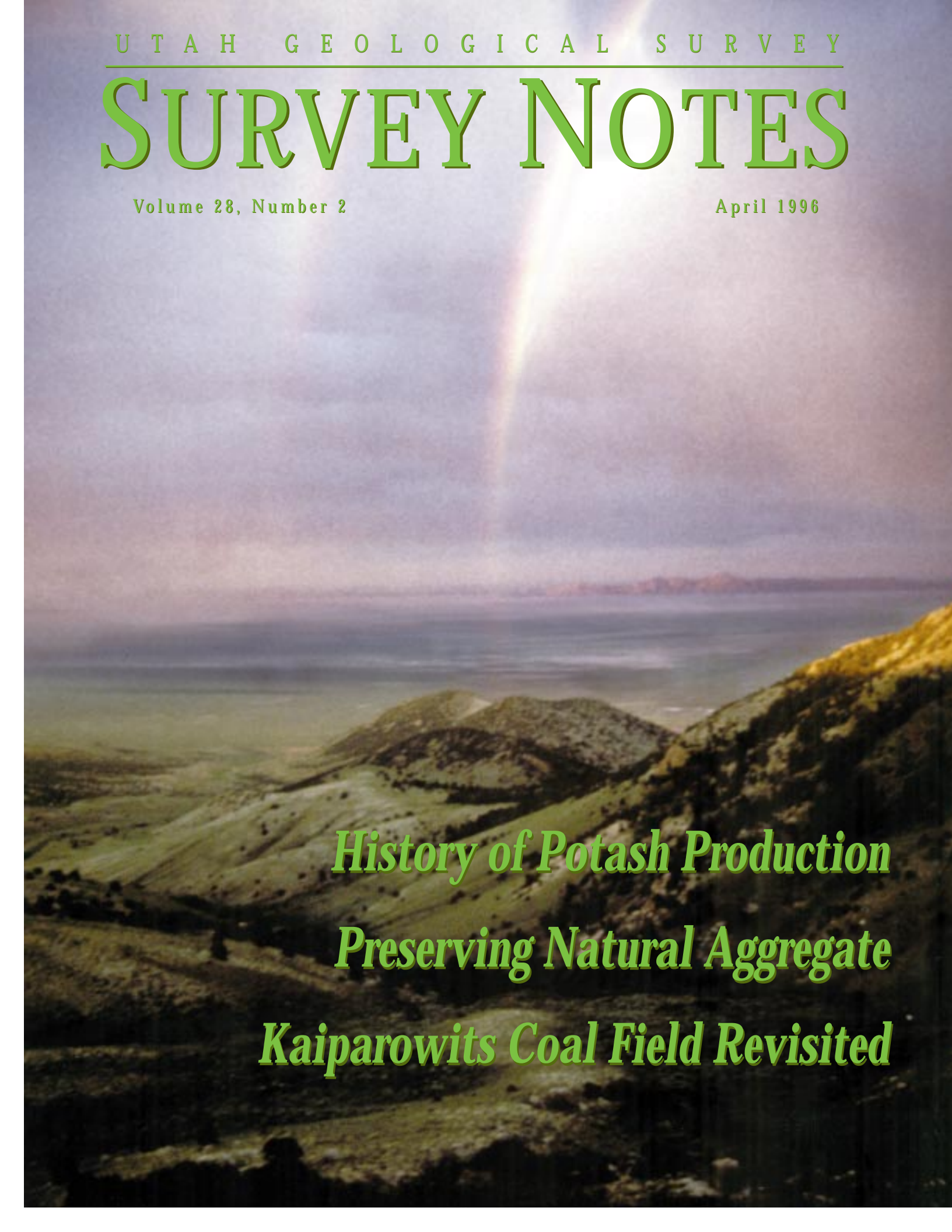


U T A H   G E O L O G I C A L   S U R V E Y

# SURVEY NOTES

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A landscape photograph of a desert valley with rolling hills and a rainbow in the sky. The rainbow is a bright, multi-colored arc that stretches from the upper left towards the center of the frame. The sky is a mix of soft pinks, purples, and blues, suggesting a sunset or sunrise. The foreground and middle ground consist of dry, hilly terrain with sparse vegetation. In the distance, a range of mountains is visible under the colorful sky.

*History of Potash Production*  
*Preserving Natural Aggregate*  
*Kaiparowits Coal Field Revisited*

## TABLE OF CONTENTS

|                                    |    |
|------------------------------------|----|
| History of Potash Production . . . | 1  |
| Preserving Natural Aggregate . .   | 4  |
| Kaiparowits Coal Field . . . . .   | 6  |
| UGS Does Web and BBS . . . . .     | 7  |
| Glad You Asked . . . . .           | 8  |
| New Life for Old Copper District . | 10 |
| Data on Petroleum Industry . . .   | 11 |
| Paradox Basin Project . . . . .    | 12 |
| The Rockhouser . . . . .           | 13 |
| Survey News . . . . .              | 14 |
| Teacher's Corner . . . . .         | 15 |
| New Publications . . . . .         | 16 |

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# The Director's Perspective

by M. Lee Allison

## End of the revolution?

Starting in the early 1960s the geologic sciences underwent one of the most profound revolutions in the history of scientific discovery. Not only did plate tectonics theory sweep the entire world, it became one of the classic underpinnings of the concept of shifting paradigms.

Satellites provided global views of Earth and planetary spacecraft revealed a solar system consisting of a gaggle of dynamic worlds more bizarre than anything conceived of in science fiction books and movies.

We obtained rock samples from the deepest ocean basins and mid-ocean ridges, from the moon and probably even Mars.

Yet in spite of all this, the geologic sciences are under siege as never before in history.

The collapse of international oil prices in 1986 initiated the elimination of nearly 500,000 jobs in the U.S. including large numbers of petroleum geologists. This event marked the beginning of the end of a quarter century of unprecedented achievements in geology.

Recent plans to downsize the federal government identified three agencies to be eliminated, all of them scientific, and two of them geology related. The U.S. Geological Survey managed to survive but only after a widespread layoff and resultant psychological trauma to the survivors and the organization. The U.S. Bureau of Mines was not able to organize its defenders as effectively and is now gone.

The assault on geology is indicative of the collapse of respect for all the sciences. Television is full of programs on the paranormal and UFOs. Utah's largest school district promotes night classes in palmistry and astrology because they are great money-makers. Psychic hotlines rake in untold amounts of money from those who don't trust scientists or religion and want a certain answer.

This abandonment of science by the public is being translated into federal policy. Dr. Neal Lane, Director of the National Science Foundation, recently sounded the alert "if you don't take it as one of your professional responsibilities to inform your fellow citizens about the importance of the science and technology enterprise, then that public support, critical to sustaining it, isn't going to be there... **One thing that has been striking during this year of budget battles...is the perceived stony silence of the science and technology community...And I can assure you that this perceived lack of concern has not gone unnoticed in Washington.**"

The geologic sciences can no longer rely on the largesse of industry and government based on past accomplishments nor because of scientists supposed sterling character, moral integrity, or great vision. No, if geology is to continue to make important contributions to society we have to influence our neighbors and our policy makers. Doing 'good science' is no longer sufficient. Utah and America cannot afford to let ignorance and benign neglect determine the future role of science and technology.

Geology led a revolution in science discovery. It is now time to lead a revolution in understanding the role of science, and geology in particular, in the workings of society.

Survey Notes is published three times yearly by Utah Geological Survey, 2363 South Foothill Drive, Salt Lake City, Utah 84109-1491; (801) 467-7970. The UGS inventories the geologic resources of the state, identifies its geologic hazards, disseminates information concerning Utah's geology, and advises policymakers on geologic issues. The UGS is a division of the Department of Natural Resources. Single copies of Survey Notes are distributed free of charge to residents within the United States and Canada. Reproduction is encouraged with recognition of source.

# History of Potash Production from the Salduro Salt Marsh (Bonneville Salt Flats), Tooele County

by J. Wallace Gwynn

The first 10 to 12 miles of Interstate 80 east of Wendover, Utah traverse the seemingly endless, flat, white, salt-covered expanse of the Bonneville Salt Flats, known in the early 1900s as the Salduro Salt Marsh. The salt flats and the surrounding Great Salt Lake Desert are remnants of the bed of an ancient, large, cyclic lake whose latest cycle, called the Lake Bonneville cycle, occurred from about 32,000 to 14,000 years ago. Lake Bonneville had a depth of more than 1,000 feet, and covered an area of 20,000 square miles in western Utah plus small portions of southern Idaho and eastern Nevada. Though the water of Lake Bonneville was relatively fresh, it contained small amounts of dissolved salt, including chlorides and sulfates of sodium, potassium, and magnesium. These dissolved salts precipitated on the surface of the Salduro Salt Marsh as the lake evaporated and are the source material from which potash (pronounced pot-ash) is produced.

The Salduro Salt Marsh in particular played an important role in the early development and production of potash or potassium chloride in the United States. The major use of potash is as a fertilizer; lesser amounts are used in the chemical in-



*Solar evaporation pond covered by precipitated salt, Salduro Salt Marsh (1921-1925, Chloride Products, Inc.).*

dustry. Prior to World War I (1914-1918), Germany supplied nearly all of the growing demands for agricultural and industrial potash in the U.S. With the blockade of Germany by Great Britain during the war, however, these supplies were cut off, and the U.S. was forced to find alternative sources of potash. By the end of the war, at least 128 U.S. plants were producing potassium compounds from kelp, wood ashes, lake brines, alunite, cement dust, sugar-beet waste, blast-furnace dust, and other sources.

As early as 1906 or 1907, the existence of the salt beds of the Salduro Salt Marsh were brought to national attention by the engineers building the Western Pacific Railroad across the western Utah desert. The salt beds were soon covered by mining claims, and almost immediately the claim owners organized the Montello Salt Company, headquartered in Ogden, Utah. After several years of unprofitable attempts to produce salt, the claims were leased to the Capell Salt Company of Salt Lake City, Utah. Capell erected a small mill near Sal-



J. Wallace Gwynn received both his B.S. and Ph.D. degrees in Mineralogy from the University of Utah. Since graduating in 1970, he has spent most of his professional career working with the great Salt Lake. The last 20 years have been spent as a saline minerals geologist with the Utah Geological Survey.

Dr. Gwynn is the author of numerous publications dealing with Utah's natural resources. Published topics include: bituminous sandstones of the P.R. Springs area, oil-well brines of the Uinta and Paradox basins, subsurface brines of Sevier Lake, low-temperature geothermal resources along the Wasatch Front, and the brines and mineral resources of the Great Salt Lake. He serves on the Great Salt Lake Technical Team and the Bonneville Salt Flats Technical Review Committee, and participates in earth science education in public elementary schools.



duro, about 10 miles east of Wendover, and produced and sold common salt for a short time.

In about 1916, the Capell Salt Company merged into or was transferred to the potash enterprise of the Solvay Process Company (headquarters unknown). During the war years, the Solvay Process Company investigated many saline deposits and in 1916 began to extract potash from the subsurface brines of the Salduro Salt Marsh. The operation was constructed on the south side of the Western Pacific Railroad at Salduro station. There, in the center of the Salduro Marsh salt beds, concentric, circular canals were dug into the salt and underlying muds. Salty water, or brine, flowed into these canals, where it concentrated through the process of solar evaporation. The most concentrated brines were continually pumped inwards, over the dikes separating the outer from the inner concentric canals. Potassium-bearing salts precipitated from the highly concentrated brine within the innermost canal. From there, the salts were harvested and processed to produce potassium chloride.

Production of potassium chloride began in 1917 and, at the end of 1918, Solvay transferred its interest in the potash operation to the Utah-Salduro Potash Company (USPC). By 1920, USPC was the largest single producer

of potash in the United States. In 1921, the plant was suddenly closed, due mainly to the reduction of high war-time potash prices and the reorganization of the activities of the Solvay Process Company. After that time, USPC restricted its operations to the production of common salt.

*(Right) Wide-tired car used for transportation over the salt marsh (1921-1925, Chloride Products, Inc.).*

*(Below) Pump (elevator) used to move brine from ditch into solar-evaporation pond, (1921-1925, Chloride Products, Inc.).*

In 1919, the Bonneville Potash Corporation (BPC), formed by J.L. Silsbee of Salt Lake City, erected a potash plant at Wendover, Utah, near the Utah-Nevada border. During the period 1920 to 1936, BPC unsuccessfully attempted to commercially produce potash through the solar evaporation of brines. In 1936, a new operating company, Bonneville Limited, was formed and it built a new plant to recover potassium chloride by flotation-recovery from solar-precipitated salts. The first potash from this new plant was shipped in 1938. By 1939, Bonneville Limited was successfully producing potash and went on to become a significant, long-term potash supplier. Since that time, the operation has survived several ownership changes, and now operates under the name of Reilly Wendover.

A third company, Chloride Products Incorporated (CPI), formed in 1921 by Frank Cook and a group of California



capitalists, also attempted to produce potash from the brines of the Salduro Salt Marsh. CPI constructed canals, evaporation ponds, and a small processing plant near Arinosa, a few miles east of the Utah-Salduro operations. CPI's developmental work is recorded through at least 1925, after which no further information is available concerning their activities.

The growth and development of the potash industry on the Salduro Salt Marsh faced many challenges. The post-war decrease in potash prices made it increasingly difficult for the Utah potash companies to compete with domestic and foreign suppliers. The surface conditions on the marsh were another critical factor. During spring, the surface was normally covered with water, hindering development work, and wave action frequently destroyed dikes and filled the brine-collection ditches with sediment. Also, heavy equipment frequently broke through the salt crust and sank into the underlying mud, necessitating the invention and use of special wide metal wheels on the equipment. Hot, dry summers and cold winters, accentuated by the ever-present wind, made working conditions on the Salduro Salt Marsh unpleasant.

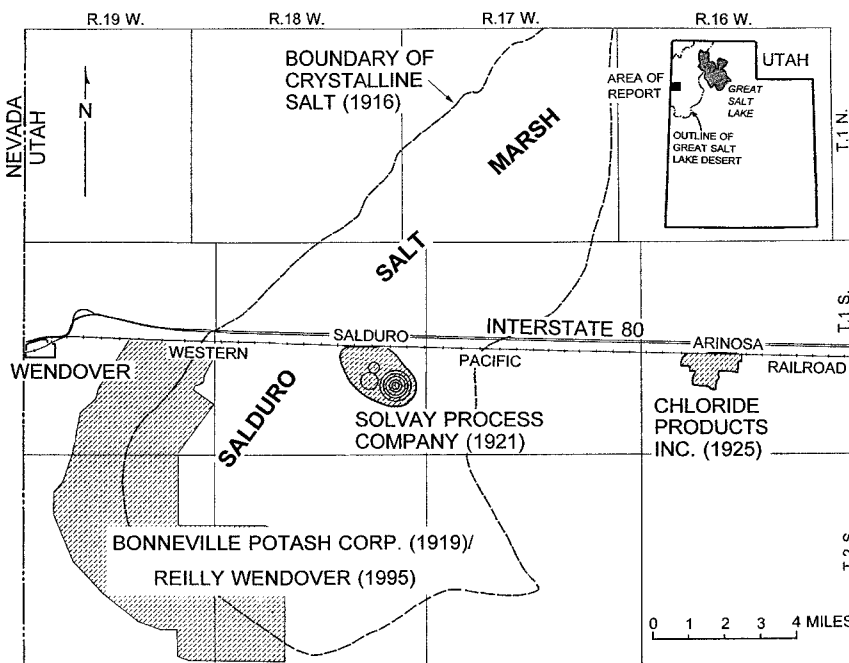
The early production of potash from the brines of the Salduro Salt Marsh by the Solvay Process/Utah-Salduro Potash Company played an important and sometimes singular role in supplying the U.S. with fertilizer during the latter part of World War I. In spite of other U.S. suppliers, international competition, and monumental



*Trenching machine building solar-evaporation-pond dikes (1921-1925, Chloride Products, Inc.).*

economical, logistical, and climatological obstacles, the potash industry on the Bonneville Salt Flats has survived. Today, Reilly Wendover, the potash industry's lone survivor on Utah's West Desert, is an important contribu-

tor to potash production in the United States, and to the economic base of both Tooele County and the State of Utah.



# Preserving Natural Aggregate for Economic Development in Washington County

by Robert E. Blackett and Bryce T. Tripp

To help local governments plan for long-term supplies of sand and gravel for buildings and infrastructure, the Utah Geological Survey (UGS) has begun a resource assessment of natural aggregate (mainly sand and gravel) in the St. George, Utah area. Whereas much of the aggregate in this area is adequate for road-base construction, high-quality aggregate for Portland cement concrete is limited. This is due to the general lack of coarse-grained surficial deposits, and also due to land-use restrictions and environmental issues. Virgin River alluvial gravel deposits southwest of St. George are generally poor sources of aggregate because they contain clasts of soft sediments and soluble minerals derived from Mesozoic-age rocks. Elsewhere, widespread secondary calcium carbonate (caliche), as rinds and matrix in gravel, lowers the quality of material.

Young river-terrace deposits in Fort Pearce Wash and along the Virgin River above St. George are the primary sources of sand and gravel for the area. Alluvial fans on the east side of the Beaver Dam Mountains and on the west side of the Hurricane Cliffs are also sources of aggregate. Stream-channel deposits associated with "inverted valleys" north of St. George and Hurricane, and older pediment gravel on the west flank of the Beaver Dam Mountains may be

future sources of high-quality aggregate.

Explosive population growth during the 1980s and early 1990s has allowed St. George and other communities in Washington County to encroach upon sand and gravel pits originally located in rural, undeveloped areas. As these communities grow, air-pollution, noise, and truck traffic generated by sand and gravel operations disturb urban residents, who then place increasing pressure on elected officials to close the pits. Pit closures effectively eliminate the remaining reserve from the area's sand and gravel resource base. Moreover, access to resources may also be lost as new

Bryce Tripp is the Geological Manager of the Economic Geology Program at the Utah Geological Survey. He has worked at the UGS since 1979.

Principal accomplishments at UGS include: assembling a mineral resource database for Utah and studying industrial rocks and minerals of the state such as high-calcium limestone, zeolites, building stone, sand and gravel. He is currently the President of the Utah Geological Association.



Sand and gravel operations along Fort Pearce Wash.

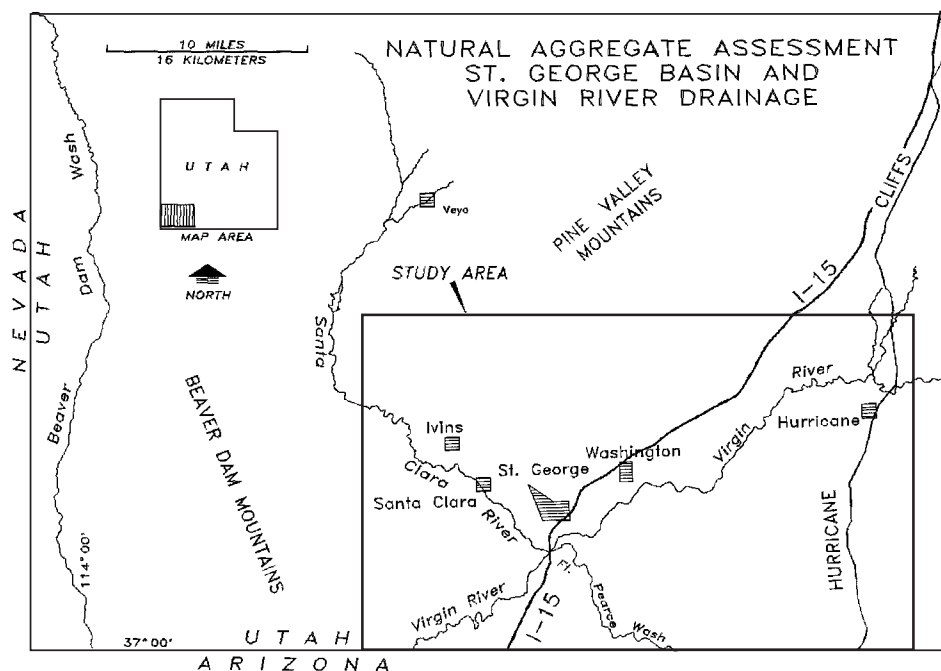


*Geographic features and study area location – assessment of natural aggregate in the region around St. George, Utah.*

homes and other buildings are built on sand and gravel deposits.

The St. George area is particularly susceptible to this type of resource loss because high-quality natural aggregate for construction is already in short supply. Moreover, most of the land in this area is administered by the U.S. Bureau of Land Management and subject to various land-use restrictions. Much of this public land cannot be developed for mineral materials, such as sand and gravel, because of federal protection for rare plants and animals, archaeological sites, and important watersheds.

As the St. George area is depleted or deprived of sand and gravel resources through extraction and urbanization, construction costs will rise unless these resources are conserved. To



help avoid this situation, the UGS has outlined a program of data gathering and field surveying of surficial deposits to determine the extent and quality of the remaining sand and

gravel. This resource information will help land planners, developers, and government officials make informed decisions concerning urban development throughout the region.

*Nearly ready for press, the geologic map of the south half of Grand County is an impressive compilation and original mapping of one of Utah's most fascinating areas. The map encompasses Arches National Park, the north part of Dead Horse Point State Park, the Colorado River from Moab to the Colorado border, part of the Book Cliffs, and the north part of the La Sal Mountains.*

*The author, Hellmut Doelling, has been Senior Geologist of the Mapping Program and very involved in geologic exploration of the Grand County area for many years. This map, at a scale of 1:100,000 or 1 inch = 16 miles, is the most detailed of its kind in existence at this time, and will provide basic geologic information for decades.*

*Its release will be announced in Survey Notes and on our new website (see Bill Case's article in this issue).*



# Kaiparowits Coal Field Revisited

by Robert E. Blackett

New information on coal seams in one of the largest coal fields in Utah - the Kaiparowits field (estimated greater than 10 billion tons of coal in-place) - was recently released in Utah Geological Survey (UGS) Open-File Report 314. The Kaiparowits Plateau extends across the southern part of Garfield County and east-central Kane County from the East Kaibab monocline (The Cockscomb) on the west to the Straight Cliffs on the east, although many people only think of the scenic Fifty Mile Mountain area as composing the Kaiparowits Plateau. The Kaiparowits coal field extends northwest to southeast for 25 miles and east to west for 18 miles through the center of the Kaiparowits Plateau. The study was an outgrowth of a UGS investigation of mineral resources in Bureau of Land Management (BLM) wilderness study areas in Kane County, and involved interpreting coal-bed intercepts on drill logs taken from 176 exploratory drill holes. Tabulated summaries of log interpretations and 560 measured sections are presented in the open-file report.

The John Henry Member of the Straight Cliffs Formation, a complex of alluvial-fluvial-deltaic sedimentary rocks of Cretaceous age, contains major, economically significant coal seams. Previous publications on coal resources within the John Henry Member included mostly data from outcrops and deep, exploratory oil

and gas wells. During the 1970s, however, a number of companies evaluated the coal resource potential of the Kaiparowits field by drilling hundreds of core holes. Because most of the land explored by these companies is public land administered by the BLM, copies of the drill logs were placed in secured files in the BLM State Office. In accordance with a Memorandum of Understanding between the BLM and the UGS, copies were also placed in secured files at the UGS. The UGS has permission to use these data to determine regional trends and prepare derivative reports and maps.

Data from exploratory holes drilled by various companies and measured sections taken by the UGS and the U.S. Geological Survey (USGS) were combined to illustrate the distribution of coal resources in the southern part of the Kaiparowits coal field. Exploratory drill holes within the main part of the coal field intersected as many as 20 coal beds of minable thickness. Total thickness of all coal beds penetrated by drill holes exceeds 80 feet over much of the field and exceeds 100 feet in localized areas.

Underground mining potential varies across the field with respect to coal, overburden, and interburden thicknesses. Near Fifty Mile Mountain, coal beds pinch out against marine sandstone, which is exposed along the Straight Cliffs. Southwestward, to-

*For the past 25 years, Robert Blackett has worked for a variety of companies engaged in energy and mineral-related activities. For the last eight years, he has done geological studies involving geothermal energy, coal, and industrial mineral resources for the Utah Geological Survey.*



ward The Cockscomb, coal beds of the John Henry Member become thin. In the west-central part of the field, sedimentary rocks covering the John Henry Member are nearly 3,000 feet thick across a broad area. Little is known about the coal beds in the western part of the field because of a lack of drill-hole data in this area of thick overburden. Measured sections taken from coal outcrops on the southern edge of the Kaiparowits Plateau, however, suggest that the coal beds thin westward.

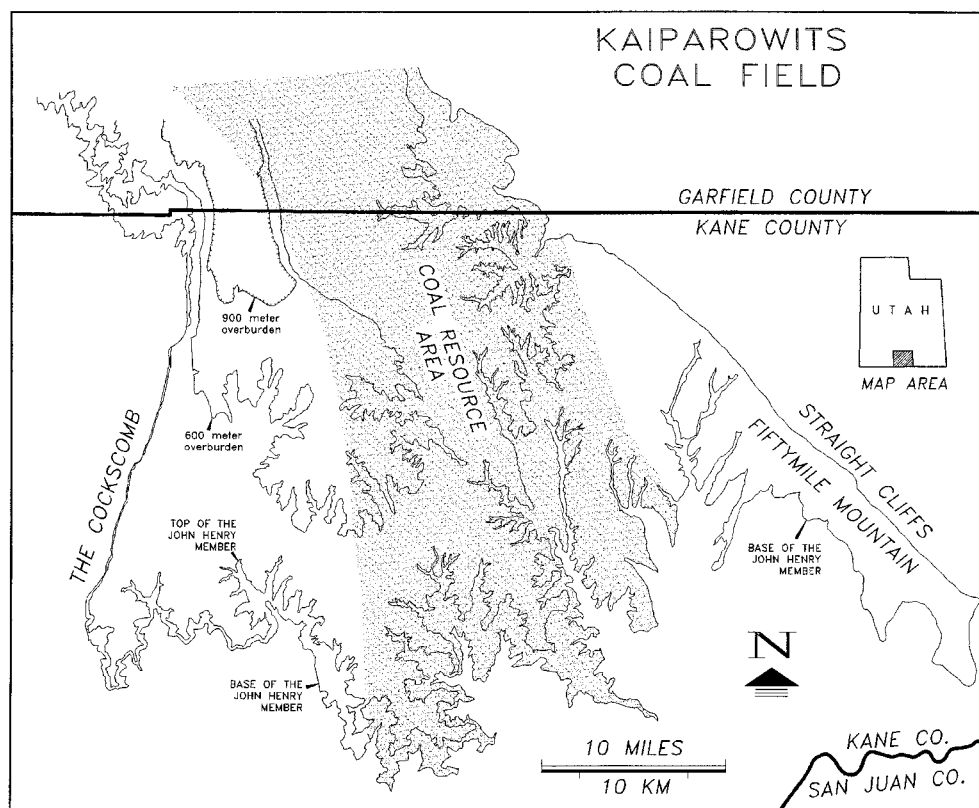
The UGS is pursuing coal and coalbed-methane research projects in cooperation with the USGS and other organizations for the Kaiparowits Plateau field. More detailed analyses of existing Kaiparowits drilling data



could provide better coal-seam and stratigraphic models and could lead to revised indicated coal-reserve estimates upward from previous estimates of 4 to 5 billion tons in-place. Detailed coal-petrography and other analytical techniques performed on core samples could provide insights regarding the potential coalbed methane resources. These combined efforts should lead to a more complete picture of energy resources of the Kaiparowits region.

Ask for our *Coal Publications* sheet by calling (801) 467-0401, faxing the UGS Bookstore at (801) 467-4070, or net us at [nrugs.geostore@email.state.ut.us](mailto:nrugs.geostore@email.state.ut.us) and we'll send one to you.

*Location of the Kaiparowits coal field showing the principal coal-resource area, geographic features, overburden contours, and the outcrop of the John Henry Member of the Straight Cliffs Formation (Cretaceous).*



# Utah Geological Survey Does Web and BBS!

by William F. Case

The Utah Geological Survey has a web site on the Internet and a BBS (bulletin board system) conference on UTAHNET, the Utah State Bulletin Board. The web site address for the Utah Geological Survey home page is <http://utstdpwww.state.ut.us/~ugs/> and the phone number for the UTAHNET BBS from the Salt Lake City area is 538-3383, and 800-882-4638 from Utah sites outside of the Salt Lake City area.

The UGS home page contains data files concerning Utah's geologic hazards, energy resources, mineral resources, and geologic maps. The latest news releases, employment opportunities, *Survey Notes* articles, professional society news and events are

also available on the home page. There is information of interest to rock hounds and public school teachers. Many of the files can be downloaded. There are links to other geology web sites, graduate student home pages, contact research summaries, and the UGS Bookstore.

The UGS Bookstore home page has **lists** including UGS and geology society publications sorted by keywords; all of the topographic maps of Utah, selected geologic maps and trail maps; coffee table books; and gift items such as tee shirts, map aides, fossil casts, and posters.

The UTAHNET BBS conferences con-



tain text files that can be read directly, and compressed files of large documents with graphics which cannot be viewed on the BBS, but can be downloaded. Communication parameters for UTAHNET are 8 bits, 1 stop bit, duplex mode, no parity. The UGS Bookstore is conference number 32; the Utah Geological Survey is a sub-conference of the Department of Natural Resources (DNR) conference number 20. Most of the files available on the Internet home pages may be downloaded from the UGS Bookstore conference.

# “Glad You Asked”

by Rebecca Hylland

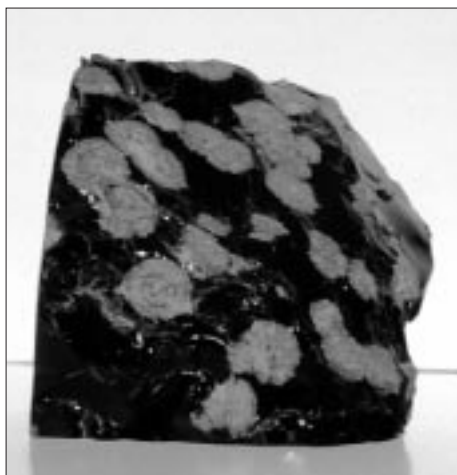
## *Igneous, Sedimentary, and Metamorphic Rocks*

What are igneous, metamorphic, and sedimentary rocks and their associated rock types? A rock is a rock, right? Not to geologists. To aid in their study of the earth, geologists group rocks into three categories based on their origin: igneous, sedimentary, and metamorphic. Each category is then further subdivided.

### Igneous Rocks

**Igneous rocks** are those that solidify from a molten or partially molten state. These rocks are characterized as either **extrusive** or **intrusive**. Extrusive igneous rocks solidify from molten material that flows over the earth's surface (lava). Extrusive igneous rocks typically have a fine-grained texture (individual minerals are not visible unless magnified) because the lava cools rapidly when exposed to the atmosphere, preventing crystal growth. Intrusive rocks form from molten material (magma) that flows and solidifies underground. These rocks usually have a coarse texture (individual minerals are visible without magnification), because the magma cools slowly underground, allowing crystal growth.

Common extrusive rocks are **basalt**, **andesite**, and **rhyolite**. Basalt is characteristically a dense, black, massive rock, high in calcium and iron-magnesium-bearing minerals and low in quartz content. Great examples of basaltic lava flows can be found in the



*Snowflake obsidian is an extrusive igneous rock. Obsidian is volcanic glass that forms when molten lava cools very quickly. The “snowflakes” in the obsidian are a variety of quartz called cristobolite.*

Black Rock Desert, Millard County. Andesite has a higher quartz content than basalt and is usually lighter in color. Crystals of the minerals amphibole, biotite, and feldspar are sometimes visible without magnification. In Utah andesite can be seen at Signal Peak in the Tushar Mountains, Piute County. Rhyolite is typically a fine-grained, white, pink, or gray rock, high in quartz and feldspar content with some amphibole and biotite. A well-known example is the Topaz Mountain rhyolite in the Thomas Range, Juab County.

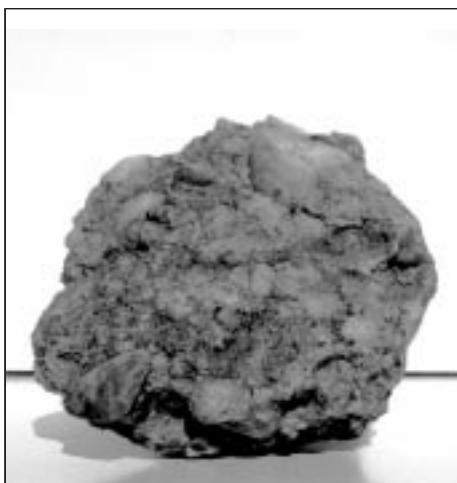
Common rock types within the intrusive category are **granite** and **diorite**. Granite is the intrusive equivalent of

rhyolite but has a coarser texture. A 12-square-mile outcrop of granite is visible on the southwestern flank of the Sheeprock Mountains, Tooele and Juab Counties. Diorite has the same texture as granite but has the mineral composition of an andesite, which is diorite's extrusive equivalent. Diorite forms the summits of Haystack Mountain, Mt. Tomasaki, Mt. Mellenthin, and Mt. Tuckuhnikivat in the La Sal Mountains, Grand and San Juan Counties.

### Sedimentary Rocks

Erosion and deposition play a key part in the formation of **sedimentary rocks**. Wind, water, ice, and chemicals break down existing rock into sediment that is then transported and deposited by wind, water, and glaciers. As sediment accumulates with time (thousands of years) it becomes compacted and cemented (lithified), eventually forming rock.

Some common sedimentary rocks are **shale**, **sandstone**, **limestone**, and **conglomerate**. Over a period spanning hundreds of millions of years, oceans, rivers, and great deserts covered Utah and deposited the sediment that has lithified into the sedimentary rocks we see today. Shale is lithified clay and consists of layers that typically break into thin sheets. A well-known shale formation is the Wheeler Shale of the House Range, Millard County, which contains numerous Cambrian



*Sediment deposited as sand and gravel has lithified and formed this conglomerate rock.*

Period (500 to 570 million years ago) trilobite fossils that are found by splitting the shale along its layers. Another shale formation is the widespread Mancos Shale, visible along Utah State Highway 6 between Price and Interstate 70, Carbon and Emery Counties. Sandstone is composed of cemented sand grains and is the cliff-forming rock commonly seen in southern Utah. Two famous formations are the Entrada Sandstone visible in Arches National Park, and the Navajo Sandstone which forms Checkerboard Mesa in Zion National Park. Limestone is composed of more than 50% calcium carbonate (calcite). The remainder of the rock may contain fine rock fragments, clay, quartz, and seashells. A limestone that is readily visible is the Bridal Veil Member of the Oquirrh Formation, at Bridal Veil Falls, Utah County. The Twin Creek Limestone can be viewed at the cement quarry near the mouth of Parley's Canyon, Salt Lake County. Conglomerate is well-rounded gravel in a matrix of sand, clay, and natural cementing agents. Two of the many conglomerates in Utah are the Price River Formation visible along Highway 6 between Thistle and Soldier Summit, Utah County, and the Shinarump Conglomerate Member of the Chinle Formation exposed along the

*The dark and light bands of gneiss are the most notable feature of this type of metamorphic rock.*

central part of the Burr Trail, east of Boulder, Garfield County.

## Metamorphic Rocks

**Metamorphic rocks** are any rock type that has been altered by heat, pressure, and/or the chemical action of fluids and gases. Metamorphic rocks are classified by their structure and their dominant minerals. Metamorphic rock structure is either **foliated** (has a definite planar structure) or **nonfoliated** (massive, without structure).

Common foliated metamorphic rocks are **slate**, **phyllite**, **schist**, and **gneiss** (pronounced "nice"). Slate is fine grained, dense, and brittle and is a metamorphosed form of shale. Slate can be seen west of Patters spring in the Pilot Range, Box Elder County. Phyllite is similar to slate but has a satin-like sheen on its foliation planes. Phyllite can be seen on the north and south flanks of Grizzly Peak east of Willard, Box Elder County. Schist has the same satin-like sheen as phyllite but has a coarse texture due to its high mica (muscovite or biotite) content. The Little Willow Formation is a schist that is visible on the north side of the mouth of Little Cottonwood Canyon, Salt Lake County. Gneiss is a high-grade (high heat and pressure) metamorphic rock in which the foliation results from a layering of different mineral groups, which give this rock a banded look of dark (mica, amphibole, and other iron-magnesium

minerals) and light (quartz and feldspar) minerals. Good examples of gneiss are visible in the Farmington Canyon Complex in Farmington Canyon, and at Fray Peak on Antelope Island, both in Davis County.

Common nonfoliated metamorphic rocks are **quartzite** and **marble**.

Quartzite is typically a metamorphosed form of sandstone. Unweathered quartzite has a "sugary" looking surface. Individual quartz grains are deformed, interlocked, and fused together. When the rock breaks, it typically breaks through the grains. Some quartzite formations retain their original bedded (layered) structure such that when broken they form flagstones that are commonly used in landscaping or as veneer for buildings. Quartzite is quarried from the Raft River and Grouse Mountains for use as building stone. It can also be seen at Storm Mountain in Big Cottonwood Canyon, Salt Lake County. Marble is metamorphosed limestone. The calcite crystals in marble are large and interlocking, forming a dense crystalline rock. Marble of the Deseret Limestone and Gardison Formation can be seen in Big Cottonwood Canyon, Salt Lake County.

A useful introduction to the Utah stone used for building materials (including many mentioned here) is the color brochure "Utah Stone" available for 25 cents from the UGS bookstore.





# New Life for an Old Copper District

by Robert W. Gloyn



Utah may soon have a new copper mine in San Juan County. While not nearly as large as Kennecott's Bingham Canyon mine, the Lisbon Valley mine could provide 105 full-time jobs and have a significant effect on the local economy. The property is leased by Summo Minerals Corporation of Denver, Colorado and is located approximately 35 miles southeast of Moab in northeastern San Juan County.

The deposit is classified as a sedimentary copper deposit. Ore consists of copper sulfides (chalcocite, covellite, djurleite, and chalcopyrite) and their oxidized equivalents (malachite, azurite, tenorite, and native copper) as coatings on fractures, as pore fillings in sandstone, and as replacements of plant fragments and entrapped hydrocarbons. Host rocks are permeable sandstones of the Cretaceous Dakota and Burro Canyon Formations. The ore occurs as a series of stacked lenses or zones in favorable formations adjacent to the Lisbon Valley fault. Oxidizing copper-rich fluids came up the Lisbon Valley fault and spread out along favorable horizons in the sedimentary rocks where the copper was precipitated by indigenous (carbon trash and plant fragments) or introduced (hydrocarbons

and dead oil) reductants in the host sandstones.

A recent feasibility study indicates a 15+ percent rate of return for a 12,000+ ton per day open-pit, heap-leach operation with a 3,000 gallon per minute solvent extraction/electrowinning plant. With full production the mine should produce 34 million pounds of cathode copper per year over the minimum 10-year mine life. Capital costs are estimated at \$47.8 million and direct operating costs at \$0.49 per pound copper. Production is scheduled to begin in 1997.

In a heap-leach operation, ore is placed on lined leach pads and sprinkled with a weak sulfuric-acid solution. The sulfuric acid dissolves the copper and the resulting pregnant liquor containing the dissolved copper is sent to a solvent extraction-electrowinning plant where it is concentrated and the copper precipitated. The procedure has the advantages of producing a high-purity copper and not requiring an expensive capital investment for the plant.

Production will be from three open pits named from north to south as the Sentinel, Centennial, and GTO pits. Current minable reserves are 42.6 million tons of 0.43 percent copper. Most

*Robert W. Gloyn joined the Utah Geological Survey in 1988. Prior to joining the Survey, he worked in the mineral industry for 21 years as an exploration and mine geologist in the United States, Latin America and Australia concentrating on uranium and base and precious metals deposits. He is currently a Senior Geologist with the Economic Geology Section specializing in metallic mineral deposits.*



of the reserves are in the Centennial deposit area. The property was mined in the early 1970s and produced about 25 million pounds of copper.

Summo Minerals Corporation has been exploring the property since 1993 and has drilled more than 100 holes to date to confirm and expand the reserves. There are now more than 1,000 drill holes on the property. The property was previously explored by Noranda Incorporated, Kennecott Corporation, and Sindor Resources Incorporated, among others.

# Energy News

## UGS Releases Data on Petroleum Industry in Summit County, Utah

by Roger L. Bon

The UGS recently released three Open-File Reports and a Public Information Series report summarizing the petroleum industry and exploration potential of Summit County. The reports are the result of a contract with Summit County government to promote development of the county's oil and gas industry.

Summit County is the third-largest oil-producing county in the state, producing more than 4.4 million barrels of oil in 1994. Through 1994, the county has produced a cumulative total of more than 159 million barrels of oil and 2 trillion cubic feet of gas. Although exploration peaked in the early 1980s, recent exploration and development have been highly successful using horizontal drilling and dual well-completion technology. Additionally, numerous large areas in the county remain unexplored.

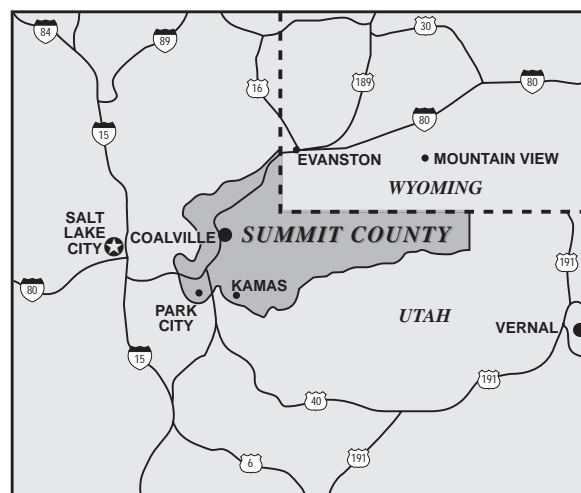
There are two oil-producing areas in Summit County containing nine active oil and gas fields. The thrust-belt area, located in the western part of the county, contains four producing oil fields and four producing gas fields. The Green River basin area, located north of the Uinta Mountains in the eastern part of the county, contains one producing oil field.

Public Information Series 31 contains an overview of exploration activity in the thrust-belt area and southern Green River basin, a production summary for the nine active oil and gas fields, and a list of the petroleum industry infrastructure in Summit

County and surrounding areas. The report also includes several maps showing the locations of pipelines, oil and gas fields and processing facilities, and mineral ownership of lands within the county.

Open-File Report 321 summarizes target areas for future exploration based on analogous structure and stratigraphy of the county's oil and gas producing fields. Ten major petroleum plays are identified, each containing exploration targets grouped by common geologic parameters. These plays represent the maximum extent of petroleum potential in a geographical area as defined by producing reservoirs, hydrocarbon shows, and untested hypotheses. Several plays overlap, delineating areas with vertically stacked traps and reservoirs. Wildcat well density in these play areas is relatively sparse, averaging 10.5 square miles per well, leaving large portions of the county relatively unexplored. Each play area is shown on a separate plate.

Open-File Report 326-DF is a compilation of geologic and production data for 323 petroleum wells in Summit County. The data are contained in six ASCII-delimited digital files that include (1) well-location data, (2) map names, (3) production data, (4) formation top data, (5) names of available geophysical logs, and (6) UGS Sample Library core availability. Each file is linked by an API number and the



database is fully relational. The database and software are self-contained and can be run on any DOS-based PC.

Open-File Report 320 is a summary of dry holes and hydrocarbon shows within the county. Dry-hole data are important because they provide both structural and stratigraphic information useful in future exploration. Drilling and test data from dry holes also indicate the presence of hydrocarbons. Test recoveries of hydrocarbons and water can be good indicators of potentially porous and permeable reservoir rock. The report contains a well-location map and summary table.

The four reports represent a comprehensive overview of the petroleum infrastructure, exploration potential, and drilling and production history of Summit County. These reports will be useful for land developers and planners as well as anyone in the oil and gas industry working in or having an interest in Summit County. Look for the order form under the heading "New Publications of the UGS" to send for your copies.

# Paradox Basin Project Set to Blast Off

by Roger L. Bon

On February 9, 1995 the U.S. Department of Energy (DOE) signed the contract for the UGS Paradox basin project. The primary objective of this cooperative agreement is to enhance domestic petroleum production by demonstrating advanced oil-recovery technology in shallow-shelf-carbonate, algal-mound reservoirs.

More than 400 million barrels of oil have been produced from various types of shallow-shelf-carbonate, algal-mound reservoirs in the Ismay and Desert Creek zones of the Pennsylvanian Paradox Formation of the Paradox basin of Utah, Colorado, and Arizona. Only 15 to 20 percent of the original oil-in-place is estimated to have been recovered during primary production from over 100 small fields in the basin. Results of the study will be published and displayed at technology-transfer sessions at industry trade shows.

This five-year, \$5 million project is funded by \$2.5 million from the DOE Class II Oil Program - Shallow Shelf Carbonate Reservoirs, and through cost share by the UGS and Harken Energy Corporation. The UGS will be the prime contractor, with Harken as its industry partner. The Utah Office of Energy and Resource Planning is also a partner on the project.

## Objectives

The geologic and engineering work on this two-phase project will characterize five shallow-shelf-carbonate reser-

voirs in the Paradox basin, all located within the boundaries of the Navajo Nation. The best candidate reservoir will be selected for a pilot demonstration project for either waterflood or CO<sub>2</sub> flooding. The technique of "flooding" is a method of secondary recovery in which large quantities of water or CO<sub>2</sub> (or other acceptable medium) are injected into the producing reservoir to displace additional oil to producing well bores, where the oil can be recovered. Field performance will be monitored to determine the success of the recovery techniques and make modifications as needed.

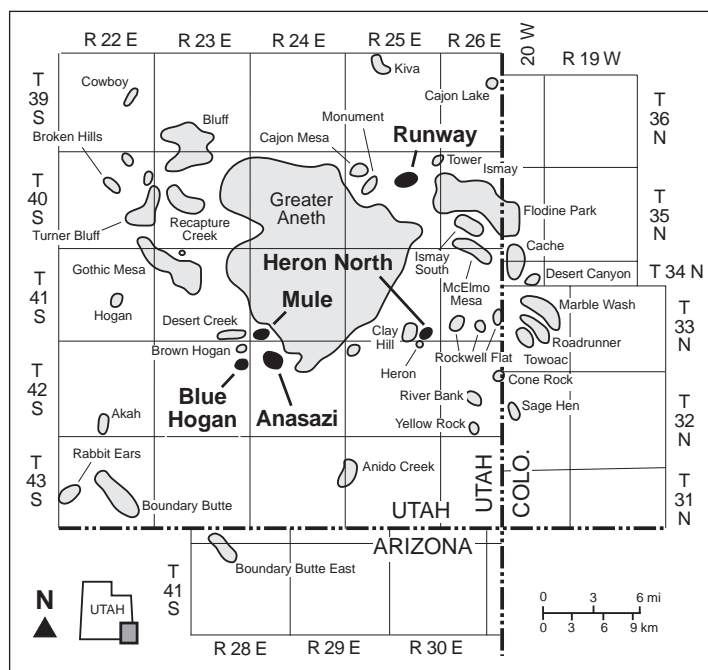
A knowledge of the reservoir characteristics of each of the various productive mound types is critical in designing secondary and tertiary recovery programs to increase the ultimate oil recovery and prolong the productive life of these and similar fields. Techniques identified during the study can be applied to other small fields in the Paradox basin, potentially resulting in a 175% increase in recovery, which equals about 150 to 200 million barrels of oil. Phase I of the Paradox basin project, to be completed in June 1996, will include geological and reservoir characterization of five small fields, evaluation of various secondary/tertiary recovery techniques by reservoir modelling, and selection of the best

field for a pilot demonstration.

Phase II (subject to DOE approval) will be a four-year demonstration project on the selected field using the secondary/tertiary technique identified as having the greatest potential for increased well productivity and ultimate recovery.

## Technology Transfer

The UGS, U.S. Bureau of Indian Affairs, Utah Geological Association, Four Corners Geological Society, and the U.S. Geological Survey are planning a Paradox basin geology symposium to be held in the fall of 1996, in Durango, Colorado. The symposium will include a guidebook, field trip(s), and conference. A Call for Papers has been issued for the guidebook. Parties interested in assisting with or planning the field trip are also being solicited. Contact Roger Bon at the UGS (801)467-7970 for further information. For those who have Internet access, the UGS home page can be located at <http://www.nr.state.ut.us/~ugs/> and will include a notice of the call for papers and, later, details of the symposium.







# The Rockhounder

## Oolitic Sand on Stansbury Island, Tooele County

by Christine M. Wilkerson

**Geologic information:** Oolitic sand is an unusual sediment that is found in and around the Great Salt Lake. Instead of forming from grains of mineral fragments washed down from higher ground, this sand formed within the Great Salt Lake. It is composed of tiny, light-brown, rounded oolites. An oolite has a shell of concentric layers of calcium carbonate that precipitated around a nucleus or central core. The nucleus is usually a tiny brine shrimp fecal pellet or a mineral fragment. Oolites form in shallow, wave-agitated water, rolling along the lake bottom and gradually accumulating more and more layers. In addition to the Great Salt Lake, oolites also form in Baffin Bay (Texas), the eastern Mediterranean Sea, the Persian Gulf, and the waters surrounding the Bahamas. Although oolitic sand is collected for its uniqueness, it has also been used to dry flowers and as flux in mining operations.

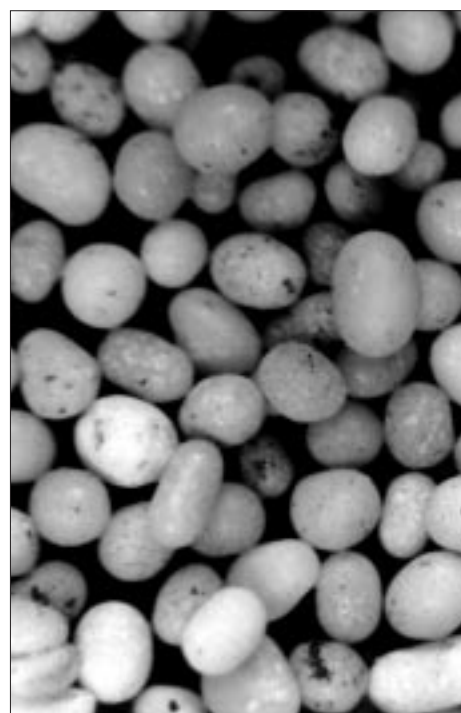
**How to get there:** Travel approximately 36 miles west of Salt Lake City on Interstate 80 until you reach the second Grantsville exit. Exit and turn west (left) onto the road to Stansbury Island (do not turn south to Grantsville). Travel about 6 miles on this main road until you reach an intersection with a stop sign on the west side of Stansbury Island. Turn west (left) and travel 0.5 miles to a sandy dune area adjacent to the road. Stop here and park on the edge of the road. Be careful not to get your vehicle stuck in the sand and watch out for the large trucks that use this road.

**Where to collect:** Oolitic sand dunes are adjacent to the road and easily accessible in this area. Use a plastic bag or a bucket to collect the sand. Be careful not to disturb the vegetation that stabilizes the dunes.

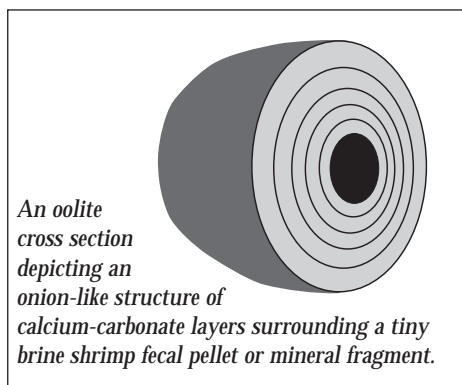
**Useful maps:** Tooele 1:100,000-scale topographic map, Corral Canyon 7.5-minute topographic map, and a Utah highway map. Topographic maps can be obtained from the Utah Geological Survey, 2363 South Foothill Drive, Salt Lake City, UT 84109-1491, (801) 467-0401.

**Land ownership:** Bureau of Land Management (BLM) public lands.

**BLM collecting rules:** The casual rockhound or collector may take small amounts of petrified wood, fossils, gemstones, and rocks from unrestrict-



*Oolites formed in the shallow, nearshore water of the Great Salt Lake. The average length of these oolites is approximately 0.5 millimeters. Photo is magnified.*



*An oolite cross section depicting an onion-like structure of calcium-carbonate layers surrounding a tiny brine shrimp fecal pellet or mineral fragment.*

ed federal lands in Utah without obtaining a special permit if collection is for personal, non-commercial purposes. Collection in large quantities or for commercial purposes requires a permit, lease, or license from the BLM.

**Miscellaneous:** A hat and water are recommended. Watch out for the large trucks that travel on the Stansbury Island roads. Respect private

property and do not trespass. Please carry out your trash. Have fun collecting!

**Extra fun:** You can also enjoy mountain biking while visiting the island. The BLM **Stansbury Island Mountain Bike Trailhead** is located about 1 mile north of the intersection with the stop sign on the west side of Stansbury Island. The trail is approximately 3 miles one-way and is steep in places. For more information contact the BLM Salt Lake District office at (801) 977-4300.

*Oolitic sand dune on the west side of Stansbury Island. The Stansbury Island mountains are in the background.*



## Survey News

### UGS to Open Regional Office

The UGS will open its first regional office in Cedar City, Utah this spring. The Southern Utah Office will be located on the campus of Southern Utah University and will serve Washington, Iron, Beaver, Piute, Wayne, Garfield, and Kane Counties. In response to the rapid growth occurring in the area, the office will focus initially on geologic-hazard projects and will provide applied-geology services to local government agencies. In the future, it is anticipated the office will offer a full range of UGS services to the citizens of southern Utah. Bill Lund, currently UGS Deputy Director, is transferring to Cedar City to open the office.

UGS has contracted with Hill Air Force Base to carry out a paleoecology study. **Dr. David Madsen** is the principle investigator.

**Steve Sommer** has finally gone for the money (and dropping a 2-5 hour commute each day) to work in the

construction industry. In 1980 when he began as an intern, Steve had no idea he'd be working in the Economic Program and looking at so many coal samples for this long. Best of luck!

Our new geotech in the Economic section is **Janae Wallace**, working for the ground-water group in Applied. Janae received her MS in geology from Northern Arizona University in 1993 and spent 2 1/2 years with the US Geological Survey's Desert Wind Project, monitoring changes in climate-sensitive areas, especially ones vulnerable to wind erosion. Janae is logging cuttings at the UGS Sample Library.

**Dan Rivers** has left the UGS bookstore for a glamorous career in the snow boarding industry. He has been picked to represent Atlantis Snow Boards.

**Trent McNair** is now working in the UGS Bookstore. He is a Computer Science major at the University of Utah, recently moving here from Boise where he was attending Boise

State University.

And, of course, **Roy Adams** is back from his long sojourn in Pakistan. He performed frontier-level petroleum exploration under contract to ESRI, and will now resume his petroleum research projects, possibly dreaming of camels.

### We're Moving

Start preparing yourselves for our move into the new building, scheduled for the end of May and June. The Department of Natural Resources will be together in one place for the first time in decades. Seven divisions comprise DNR: the UGS; Oil, Gas and Mining; Forestry, Fire and State Lands; Parks and Recreation; Water Resources; Wildlife Resources; Water Rights and, of course, Administration. The new location is 1594 West North Temple, very close to Redwood Road. We will have an expanded bookstore carrying all our publications, a plethora of hiking and hunting maps, Antelope Island memorabilia, fossils, and much more. Plan to stop by.



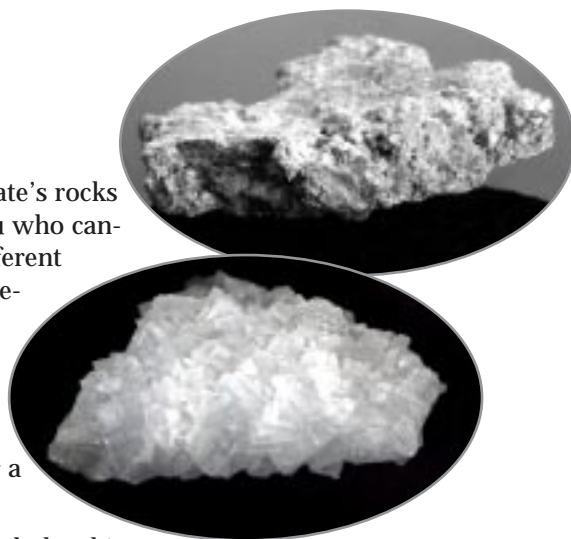
## Teacher's Corner

*By Sandy Eldredge*

### Rock, Mineral and Fossil Kits

Utah's fourth-grade teachers have been on the prowl for samples of the state's rocks and minerals. Luckily, rock and mineral kits are available for those of you who cannot spend all your time looking for rocks, let alone figuring out where different specimens are. Both the Utah Geological Survey (UGS) and the Utah Museum of Natural History (UMNH) have kits for teachers.

The UGS kits contain labeled igneous, sedimentary, and metamorphic rocks. Also provided are descriptions and Utah localities where these rocks can be found. In addition, each kit contains a bottle of crude oil from one of Utah's oil fields and fossils. Come on in and sign out a kit for a two- to three-week loan. A \$10.00 refundable deposit is required.



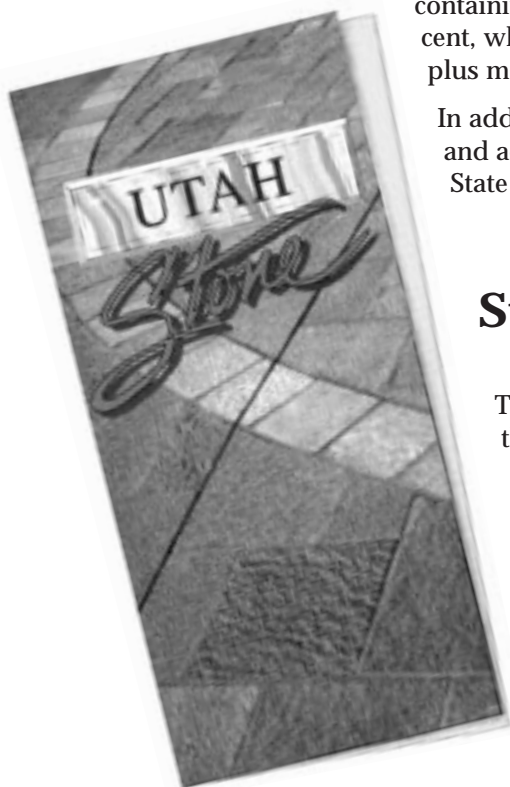
The UMNH, located at the University of Utah, has kits containing rocks, minerals, and soils of Utah. A kit can be checked out for \$5.00 or a Docent, who will talk to your class, can come to your school with the kit for a fee of \$8.00 plus mileage. For more information, call Kara Edwards at 581-4887.

In addition, Utah Mining History Teaching Kits, which include historical information and activities for fourth- and seventh-grade, are available for checkout at the Utah State Historical Society. For more information, contact Alan Barnett at 533-3536.

### Stone Brochure Poster

To go with your study of Utah's rocks, try the "Utah Stone" fold-out brochure that can be used as a poster measuring 23" x 16".

Decorate your classroom wall with colorful pictures of different varieties of lava, rhyolite, quartzite, limestone, sandstone, and granite. These rocks are quarried in Utah for use as building stone. On the reverse side is a description of each stone, where they are quarried, and how they are used (from buildings, to flagstone, to building and fireplace veneers). A list of stone quarries, stone companies and processors in Utah is included. All for only \$0.25! Call UGS at 467-0401 to order, or pick one up while you are here to check out a rock and mineral kit.





# New Publications of the UGS

**The September 2, 1992 ML 5.8 St. George earthquake, Washington County, Utah** edited by G.E. Christenson, 41 p., 1995, C-88 ..... **\$6.95**

*Seven articles discuss the effects in the area, including the Springdale landslide.*

**Guide to authors of geologic maps and text booklets of the Utah Geological Survey**, by H.H. Doelling and G.C. Willis, 98 p., 1995, C-89 ..... **\$7.95**

*A comprehensive style and method manual for mappers; suitable as a guide to any geologic mappers needing to prepare a publication.*

**Radon-hazard potential in the St. George area, Washington County, Utah**, by B.J. Solomon, 1 p., 2/96, PI-35 ..... **Free**

*Useful information sheet for non-geologists.*

**Radon-hazard potential in the Ogden Valley, Weber County, Utah**, by B.J. Solomon, 1 page, 2/96, PI-36 ..... **Free**

**Technical reports for 1994-1995, Applied Geology Program**, compiled by B.H. Mayes, 162 p., 2/96, RI-228 ..... **\$7.50**

*Each year the Applied group publishes the results of all the small investigations (site specific) done in response to calls from local, state, and federal governments as well as emergency responses*

**Maps of total Ferron coal, depth to the top, and vitrinite reflectance for the Ferron Sandstone Member of the**

**Mancos Shale, central Utah** by D.E. Tabet, B.P. Hucka, and S.N. Sommer, 3 plates, 1:250,000, 12/95, OFR-329 ..... **\$15.00**

**Second annual report - Increased oil production and reserves from improved completion techniques in the Bluebell Field, Uinta Basin, Utah** by C.D. Morgan, 115 p., + 105 p. appendix, 12/95, OFR-330 ..... **\$17.50**

**Ferron Sandstone drill-hole strip logs, Ferron Creek to Last Chance Creek, Emery and Sevier Counties, Utah** by B.P. Hucka, S.N. Sommer, D.A. Sprinkel, and D.E. Tabet, 1417 p. (in two volumes, unpaginated), 12/95, OFR-331 ..... **\$45.00**

**Hazard potential, failure type, and timing of liquefaction-induced landsliding in the Farmington Siding landslide complex, Wasatch Front, Utah** by M.D. Hyl-land and Mike Lowe, 47 p., 12/95, OFR-332 ..... **\$4.50**

**Interim geologic map of the Keg Mtn. Ranch quadrangle, Juab County, Utah** by M.A. Shubat, T.J. Felger, and J.K. King, 96 p., 2 pl., 1/96, OFR-333 ..... **\$10.50**

**Major levels of Great Salt Lake and Lake Bonneville**, by D.R. Currey, G. Atwood, and D.R. Mabey, 1983, 1:500,000, Map 73 (reprint) ..... **\$5.00**

*This popular map, back in print after a two-year hiatus, depicts the water levels in a clear and understandable manner. Very useful for teachers and hikers trying to understand the valley benches.*

Mail or Fax order to:

## SALES

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**Interim geologic map of the Jump Creek quadrangle, Carbon County, Utah** by C.D. Hansen, 2 pl. 3/96, 1:24,000, OFR-334 .....\$4.00

**Mineral, energy, and ground-water resources of San Juan County, Utah** by R.W. Gloyn, C.D. Morgan, D.E. Tabet, R.E. Blackett, B.T. Tripp, and M. Lowe, 39 p., (18.5" x 15.5"), 1995, SS-86 .....\$10.00

*A complete summary of the geologic aspects of San Juan County known to date. This volume was originally intended to convey sufficient information to make planning decisions, but has been expanded. There are 15 plates at 1:500,000 delineating the geologic aspects covered in the text.*

**Paleoseismology of Utah Volume 6: The Oquirrh fault zone, Tooele County, Utah:** surficial geology and paleoseismicity, W.R. Lund, editor, 64 p., 2 pl., 1:24,000, 1996, SS-88 .....\$14.50

*Another in the series dedicated to making paleoseismic data available to provide critical information on earthquake timing and recurrence and related subjects. Two papers are included. "Surficial geology of the Oquirrh fault zone, Tooele County, Utah" is by Barry Solomon and includes a 1:24,000 colored geologic map; the second is "Paleoseismic investigation of the Oquirrh fault zone, Tooele County, Utah" by Susan Olig, Bill Lund, Bill Black, and Bea Mayes with a detailed log of the Pole Canyon trench.*

**Canyon Country: a geologic guide to the Canyonlands travel region,** by S.N. Eldredge, 25 p. color, 1996, PI-34 .....\$1.95

*Very bright, very informative guide. See ad on back cover.*

**These four releases are the ones mentioned in Roger Bon's article on page 11:**

**Petroleum production and well data, Summit County, Utah** by D.A. Sprinkel, 12 p., 2 diskettes, 7/95 OFR-326DF .....\$10.00

**Oil and gas in Summit County, Utah,** compiled by R.L. Bon, information brochure, 1995, PI-31 .....\$1.00

**Dry holes and hydrocarbon shows in Summit County, Utah,** by C.D. Morgan, 9 p., 1 pl., 1"=6.25 miles, 5/95, OFR-320 .....\$3.00

**Petroleum plays in Summit County, Utah** by T.C. Chidsey, Jr., 25 p., 10 pl., 1"=6.25 miles, 6/95, OFR-321 .....\$5.00

## Other Publications & Meetings of Interest

(Not available from UGS)

**Navajo Country, a geology and natural history of the Four Corners region,** by D.L. Baars, 1995, University of New Mexico Press. A popular geology centered on Navajo cosmography. Very useful for travellers by lacing together geologic interpretation with history and Navajo creation stories for a much broader view of this area. Although written for the layman, the text depicts the geology accurately.

**"Making water part of your planning process"** is the 2nd Annual Ground Water Conference to be held May 8-9 at The Homestead in Midway, Utah. Geared toward planning professionals, citizen planners, and water professionals, it will also have a field trip featuring Wasatch County planning efforts.

**Call for papers for 1996 GSA Annual Meeting** in Denver, October 28-31. Abstract deadline is July 9, 1996. Contact GSA Abstracts coordinator, P.O. Box 9140, Boulder, CO 80301-9140, or call 303-447-2020, ext. 161, or email ncarlson@geosociety.org.

**November 10-14, 1996, Society of Economic Geologists,** annual meeting in Denver, CO. Contact: <http://www.gg.utah.edu/SEG>.

**October 6-9, 1996, Society of Petroleum Engineers** meet in Denver, CO. Contact SPE Meetings Department, P.O. Box 833836, Richardson, TX 75083-3836.

**July 28-31, 1996, AAPG Rocky Mountain Section** in Billings, Montana. Contact AAPG Convention Department, 918-560-2679.

# CANYON COUNTRY

## A Geologic Guide to the Canyonlands Travel Region

by Sandra N. Eldredge

A colorful guide to the highways and scenic drives in the Canyonlands travel region which includes Arches and half of Canyonlands National Parks; the Manti-Lasal National Forest; part of Glen Canyon National Recreation Area; Natural Bridges, Rainbow Bridge, and Hovenweep National Monuments; and many others in Grand and San Juan Counties. Included are an easily understood chart of the rock formations you'll see, photos of the truly fascinating geologic phenomena with explanations of their development, and a map of the area. Fold-out pages provide tours of Scenic Byways 128, 279, U-211, US-163, and the Bicentennial Highway. Well worth the price!

PI-34 ..... \$1.95

This issue of Survey Notes cover: Southeast view from Pilot Peak looking at the Silver Island Range, Great Salt Lake Desert, western Utah. Photo by Monson W. Shaver III.



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